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VIVIPARY IN PODOCARPUS *

By Francis E. Lloyd

An interesting case of vivipary, one which appears to be more or less widely known, but, nevertheless, unrecorded † is that which occurs in *Podocarpus Makoyi.* It is quite probable that the same thing occurs in some other species of the genus. During the past winter a specimen of this species some four feet in height has produced, in the conservatory of the New York Botanical Garden, an excellent crop of fruits, and these have, almost without exception, germinated, and this on the tree, so that the plant presented, for a greenhouse plant, a very unique and interesting appearance. A shoot, bearing a germinating seed, is shown in Fig. 1.

The ovules of *Podocarpus Makoyi* are produced laterally in the axils of the leaves. They are provided, as are all the Taxaceae, with a fleshy, aril-like organ, dark purple when ripe (*int. 2*, Fig. 2), which is generally regarded as an outer integument. Surmounting this is the glaucous green, oval body, consisting, when young, of nucellus and integument (inner integument, according to the terminology here used, *int. 1*, Fig. 2), which corresponds to the similar body deeply buried in the pit of a *Taxus* fruit. From this, however, it differs in the fact that in *Podocarpus* it comes into an anatropous position. The micropyle is then so placed as to lie against the fleshy outer integument (Fig. 2, *c*).

* Read at a meeting of the Torrey Botanical Club, May 13, 1902.

† I learn from Mr. K. Miyake that the phenomenon is, as would be expected, well known in Japan and has probably been described in Japanese ; it has also been observed before in cultivation elsewhere.

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When the fruit has arrived at maturity, the embryo (*e*, Fig. 2, *c*) then occupies a cylindrical cavity in the endosperm (*end*, Fig. 2, *c*) which, rich in food materials, occupies the whole space in the interior of the inner integument. The end of the radicle of the embryo then lies close to the micropyle, and it is at this stage in its development that, were it not for the viviparous habit, the seed would enter the resting condition. As it is, however, the embryo keeps up its growth, and very soon the

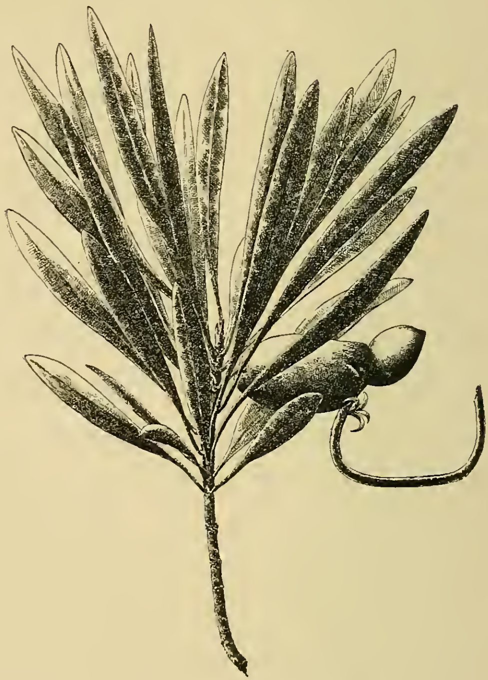

FIG. 1. A shoot of *Podocarpus Makoyi*, bearing a germinating seed.

root end of the embryo breaks through the micropyle. The relative position of the two regions of the ovule above distinguished, together with the positive geotropy of the root pole of the embryo, causes the radicle, and later the hypocotyl, to bend downwards. How far the geotropic stimulus affects the matter is however not clear, for, either on account of the weak response, or as a result of unequal growth on the two sides of the hypocotyl, the axis continues its growth in a curve, so that, when the whole of the hypocotyl is exposed, it lies in the arc of a circle, approximately (Fig. 1, *h*; Fig. 2, *a*). The process of curving does not always cease even after the fruit falls from the tree, but continues as the seedlings lie upon the ground until, in many cases, the hypocotyl makes a complete loop. These curvatures are frequently fixed by growth so that in older seedlings the irregularities are still to be seen. The absence of geotropic response may be only apparent, inasmuch as growth is very slow, and the tissues of the exposed axis are rendered cumbersome by the load of food materials.

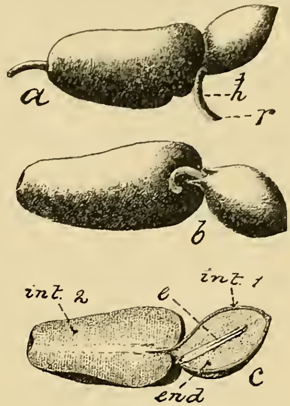

FIG. 2. *a*, lateral view of fruit during early stage of germination; *b*, dorsal view, and *c*, longitudinal section, of same; *e*, embryo, *end*, endosperm; *int. 1*, *int. 2*, inner and outer integuments; *h*, hypocotyl; *r*, radicle.

The hypocotyl is, when developed, of that club shape (Fig. 3) characteristic of certain other viviparous plants, as the mangroves. It is very rich in food materials, especially starch, derived not alone from the endosperm but as a result of its own activity in starch-making. This is evident from the greater weight of the hypocotyl and from its green color. Stomata are present, also, in numbers upon the hypocotyl.

FIG. 3. A seedling, and the lower end of another showing two lateral roots.

Under the cultural conditions in which the plant under discussion was growing, the radicle, which forms but a mere tip of the axis, was frequently found in a withered condition. The primary root of the embryo is, in fact, often destroyed. For this reason, when the embryos, usually together with the other seed-parts, finally become detached from the tree and become established in the soil, the primary root axis does not, at least in many cases, develop. In its stead, however, one, or usually two, secondary roots (Fig. 3) are formed in the usual manner, *i. e.*, laterally, very close to the end. As a result of the mechanical relations of the tissues, these are from the start forced to grow parallel to the chief axis, and thus take the place of the chief root. That this substitution of lateral hypocotyledonary (adventitious) roots actually takes place can be shown by the intentional destruction of the chief root, which, as above stated, sometimes takes place by withering. The same thing may be induced higher up in the hypocotyl by removing the lower end by a transverse cut. Lateral injuries of various forms, even when they extended as far as the central cylinder, did not stimulate the formation of new roots, nor does this occur, excepting at the extreme lower end after longitudinal splitting of the hypocotyl. The growth of these lateral roots is considerably slower when the end is removed, from which it appears that the tissues are the less able to form roots, the further the point of injury is from the original radicle. A month to six weeks may elapse before the fundaments of these new roots may be readily seen, and the general development of the seedling is correspondingly slow. The plumule is, however, often well developed before the seedling becomes separated from the tree (Fig. 1).

A very interesting case of vivipary is recently reported by Dr. O. Stapf* to occur in one of the tropical grasses (*Melocanna bambusoides* Trin.) of the forests of Bengal. In this plant the endosperm (presumably in the mature fruit) is lacking, while the testa and pericarp are specialized to form nutrient tissues. The scutellum is very considerably enlarged and occupies the space otherwise filled by the endosperm. The scutellum, which is richly supplied with vascular tissues, acts, during germination, upon the pericarp in a manner analogous to its action in other grasses on the endosperm. Dr. Stapf believes that certain other genera (*Melocalamus* and *Ochlandra*) offer similar conditions.

Dr. J. K. Small has reported vivipary to occur in *Tillandsia*

* Nature, **65** : 548. 10 Ap. 1902.

Balbiviana Small and in one of the southwestern oaks, *Quercus fusiformis* Small. It is interesting to note in this connection that in certain of our common oaks (*Quercus rubra* L., *Q. palustris* DuRoi, *Q. coccinea* Wang., and *Q. velutina* Lam.) while vivipary, in the exact sense, has not been observed, nevertheless in these germination commences immediately upon the fruit reaching the ground in the autumn.

Vivipary, it seems, is by no means the unusual condition it has generally been supposed to be.

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A KEY TO THE NORTH AMERICAN SPECIES OF RUSSULA—II *

By F. S. Earle

Section 3, Rigidae

1.	Pileus dry, smooth, glabrous.†	2.
	Pileus pruinose, furfuraceous, areolate, etc.	5.
2.	Pileus white or tinted.	3.
	Pileus deep red or bright red.	4.
3.	Taste mild; pileus often rose-tinted.	*R. albella* Pk.
	Taste acrid; pileus pure ivory-white.	*R. albidula* Pk.
4.	Stipe white or reddish-white; pileus cinnabar-red, acrid.	*R. rubra* Fr.
	Stipe blood-red; pileus blood-red or purplish-red.	*R. Linnaei* Fr.
5.	Pileus pure white, then alutaceous, rivulose.	*R. lactea* (Pers.) Fr.
	Pileus yellow, paler with age, slightly mealy.	*R. flavida* Frost
	Pileus grayish-brown, pulverulent or scurfy.	*R. pulverulenta* Pk.
	Pileus cinnamon, rimose, then floccose.	*R. cinnamomea* Bann.
	Pileus greenish, areolate.	*R. virescens* (Schaeff.) Fr.
	Pileus rose-red.	6.
	Pileus changeable, often dingy purple when young.	7.
6.	Pileus with disk lighter, whitish, rimose-scaly.	*R. lepida* Fr.
	Pileus with disk darker, pulverulent, shining.	*R. Mariae* Pk.
7.	Lamellae white; pileus areolate.	*R. cutifracta* Cke.
	Lamellae yellow; spores yellow; pileus silky-squamulose.	*R. olivacea* Fr.

* Continued from page 103.

† Some of the species assigned to section Rigidae are glabrous and perhaps should be excluded.